SGS

TECHNICAL NOTE 155

P.C.M. INFRARED REMOTE CONTROL SYSTEM

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INTRODUCTION

This new remote control system has been developed for remote control in consumer (TV, radio, VCRs, . . .) and industrial applications.
This system uses a very reliable PCM code (the binary information associated with each bit is determined by the distance between two successive transmitted pulses), so no wrong command can be executed.
Moreover, it has a very large instruction set (64 commands x 16 addresses), so it is very flexible in applications and, due to its address organization, allows a wide range of simultaneous applications without any interference among each system: only the receiving system with the desired address will decode and accept the transmitted command, while all the other receiving systems will reject it.
The power dissipated in transmission is very low due to a very reduced transmission duty cycle (short pulses are transmitted) so the transmitting diode can be driven with a high current – up to 1.8A), thus allowing a very large transmission distance without reducing the battery life too much.
At the receiver end, the signal, converted by a photodiode and preamplified (no AGC is required in the preamplifier) is fed to the receiver circuit. This may be the dedicated device M104 or a microprocessor which can perform the decoding function.
In order to achieve the best utilization of both receiving systems, two different types of transmission are available: flash mode (for the dedicated receiver) and carrier mode (for microprocessor decoding).
In this technical note we shall focus the attention mainly on the dedicated receiver system (flash mode transmission). For more details on the carrier mode application and explanation please refer to the technical note No. 152 (PLL 2K System).
The dedicated system has a wide frequency range (445 to 510 kHz), so cheap ceramic resonators or LC groups can be used in both the transmitter and receiver sections (due to the synchronization performed by the dedicated receiver different oscillation frequencies can be used for the transmitter and for the receiver).
Finally, also the dedicated receiver can be interfaced with a serial data bus, in order to expand the system which is remote controlled.

GENERAL SYSTEM INFORMATION

Two basic system configurations are suggested, as shown in fig. 1, depending on the receiver section: the dedicated receiver IC, M104, or a microcomputer (e.g. M387X) can be used.
The basic devices of the dedicated system are:

M709/M710 – PCM remote control transmitters

- M709: 40 command x 16 address organization
- M710: 64 command x 16 address organization
- Flash mode and carrier mode transmission
- End of transmission code
- Single contact matrix keyboard (interlock and antibounce are integrated)
- Very low power consumption during transmission
- Wide reference frequency range (nominal 455 to 500 kHz ceramic resonator)
- 4.5 to 10V power supply operating range

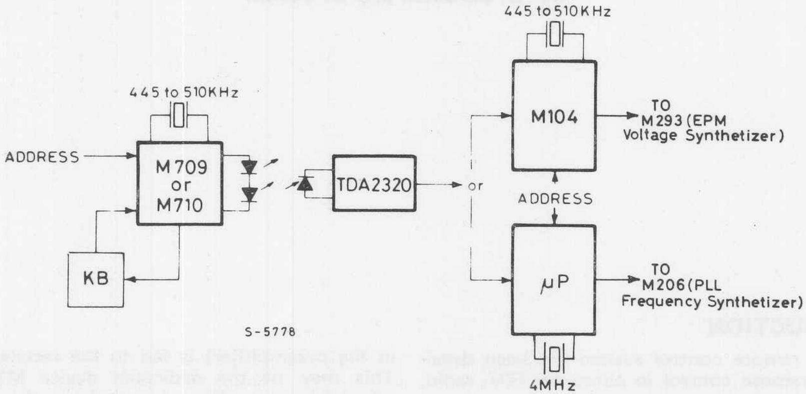
TDA 2320 – Preamplifier for I.R. Remote Control Systems

- High sensitivity and noise immunity
- Operation in flash and carrier mode
- Wide operating range (4 to 16V)

M104 – PCM remote control receiver

- 128 channel (64 commands x 2 addresses) decoding
- 5 bit static program outputs
- 4 analogue controls
- 15 local commands available
- Serial data bus
- Integrated digital power-on reset (duration ~ 125 ms)
- Wide reference frequency range (nominal 455 to 500 kHz ceramic resonator)
- 5V supply voltage

Fig. 1



DESCRIPTION OF EACH PRODUCT

Each circuit is described with reference to its function.
For more details, please refer to the data sheets.

M709/M710 Remote control transmitters

Power supply: 4.5 to 10V
Technology: Silicon gate CMOS

These devices are two PCM transmitters which use a highly reliable code with 1024 channel capacity. They can both address up to 16 different systems (with a four bit addressing): the only functional difference between the two devices concerns the number of commands that they can transmit:

M709 40 commands (640 channels)
M710 64 commands (1024 channels)

The 64 available commands are coded with 6 bits, following the truth table shown in table 1.

The address transmitted code is the binary code minus 1 (that means address 1 is transmitted as 0000 and address 16 as 1111).
A block diagram of the devices is shown in fig. 2.

Oscillator

A cheap ceramic resonator or an LC group must be connected between pins 2 and 3 with a resonant frequency of 445 to 510 kHz.

Data encoding

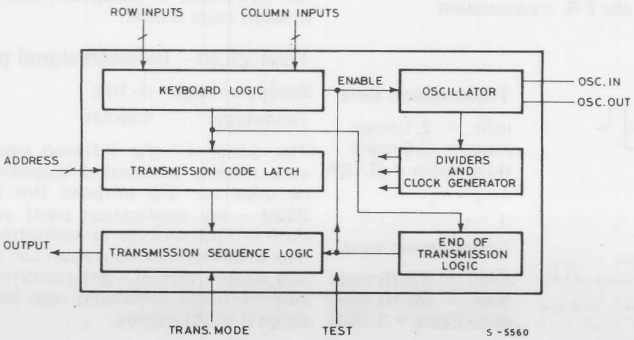
The signal are transmitted with I.R. light using a special Pulse Code Modulation known as Pulse Position Modulation.
Each transmitted word consists of 11 information bits (address bits, command bits and parity bit) and 3 formating bits. The bit sequence is as follows: 1 preliminary bit, 1 start bit, 4 address bits (A1, A2, A3, A4), 6 command bits (C1, C2, C3, C4, C5, C6), 1 parity bit and 1 stop bit.

TABLE I – M709/710 truth table

Command No.	A	B	C	D	E	F	G	H	K	I	L	M	N	O	P	Q	C1	C2	C3	C4	C5	C6
	Input code																Command bits					
0	END OF TRANSMISSION																0	0	0	0	0	0
1	X									X							1	0	0	0	0	0
2	X										X						0	1	0	0	0	0
3	X											X					1	1	0	0	0	0
4	X												X				0	0	1	0	0	0
5	X													X			1	0	1	0	0	0
6	X														X		0	1	1	0	0	0
7	X															X	1	1	1	0	0	0
8		X							X								0	0	0	1	0	0
9		X								X							1	0	0	1	0	0
10		X									X						0	1	0	1	0	0
11		X										X					1	1	0	1	0	0
12		X											X				0	0	1	1	0	0
13		X												X			1	0	1	1	0	0
14		X													X		0	1	1	1	0	0
15		X														X	1	1	1	1	0	0
16			X						X								0	0	0	0	1	0
17			X							X							1	0	0	0	1	0
18			X								X						0	1	0	0	1	0
19			X									X					1	1	0	0	1	0
20			X										X				0	0	1	0	1	0
21			X											X			1	0	1	0	1	0
22			X												X		0	1	1	0	1	0
23			X													X	1	1	1	0	1	0
24				X					X								0	0	0	1	1	0
25				X						X							1	0	0	1	1	0
26				X							X						0	1	0	1	1	0
27				X								X					1	1	0	1	1	0
28				X									X				0	0	1	1	1	0
29				X										X			1	0	1	1	1	0
30				X											X		0	1	1	1	1	0
31				X												X	1	1	1	1	1	0
32					X				X								0	0	0	0	0	1
33					X					X							1	0	0	0	0	1
34					X						X						0	1	0	0	0	1
35					X							X					1	1	0	0	0	1
36					X								X				0	0	1	0	0	1
37					X									X			1	0	1	0	0	1
38					X										X		0	1	1	0	0	1
39					X											X	1	1	1	0	0	1
40						X			X								0	0	0	1	0	1
41						X				X							1	0	0	1	0	1
42						X					X						0	1	0	1	0	1
43						X						X					1	1	0	1	0	1
44						X							X				0	0	1	1	0	1
45						X								X			1	0	1	1	0	1
46						X									X		0	1	1	1	0	1
47						X										X	1	1	1	1	0	1
48							X		X								0	0	0	0	1	1
49							X			X							1	0	0	0	1	1
50							X				X						0	1	0	0	1	1
51							X					X					1	1	0	0	1	1
52							X						X				0	0	1	0	1	1
53							X							X			1	0	1	0	1	1
54							X								X		0	1	1	0	1	1
55							X									X	1	1	1	0	1	1
56								X	X								0	0	0	1	1	1
57								X		X							1	0	0	1	1	1
58								X			X						0	1	0	1	1	1
59								X				X					1	1	0	1	1	1
60								X					X				0	0	1	1	1	1
61								X						X			1	0	1	1	1	1
62								X							X		0	1	1	1	1	1
63								X								X	1	1	1	1	1	1

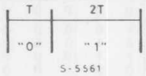
Commands not available in the M 709

Fig. 2 – M709/710 Block diagram

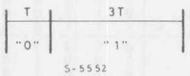


The binary information of each bit is determined by the time interval between two pulses. If T is the time base (which depends on the transmission mode), the bits are coded as shown below:

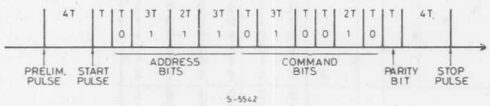
odd bits
0 = T
1 = 2T



even bits
0 = T
1 = 2T



The different code introduced for even and odd "1s" improves the noise immunity of the transmission at the receiver; for example, the double error which can cause the change "01" to "10" (and viceversa) is easily detected.
In the word a parity bit is added to increase the transmission reliability: the total number of transmitted "1s" is always odd.
The formating pulses are spaced as shown in the figure below: the distance between preliminary and start pulse is 4T, the distance between start pulse and the first information pulse is T and the distance between the last information (parity) pulse and stop pulse is 4T.



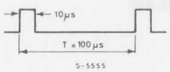
In this way, the total word time can range from 21T (command information all zeros) to 36T (command information = all ones).

Transmission mode

Both M709 and M710 can generate the transmission code in flash or in carrier mode, depending on the state of pin 1 (if it is high the transmission is in flash mode).
The difference between the two modes is the code time base T and the fact that in the "carrier" transmission mode the "pulse" consists of a burst of 38.4 kHz pulses.
The output signal has the format shown in fig. 3, using the two different modes (f_{NOM}= 500 kHz).

Fig. 3 - Format of the I.R. transmission

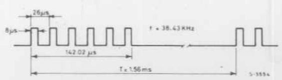
Flash mode



Transmission time

min. = 2.1 msec
max. = 3.6 msec
duty cycle = 0.15%

Carrier mode



Transmission time

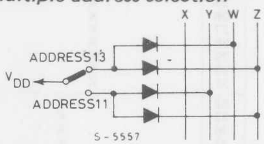
min. = 32.76 msec
max. = 56.16 msec
duty cycle = 1.05%

The carrier mode is provided for those systems in which the receiving function is performed by means of a microprocessor which, of course, cannot work well with the pulse-time typical of the "flash" mode.
The carrier modulation has been introduced in order to reduce the transmission duty cycle which is higher due to the greater width of the pulse.
Transmission duty cycle is a very important parameter because the transmitting LED power consumption depends on it. Since the repetition time of the transmitted word is the same in both cases (≃ 102 ms), the duty cycle is 0.15% for flash mode and 1.05% for carrier mode.

Address inputs

4 address inputs are provided, with internal pull-downs, which are disabled during stand-by, for power consumption reasons.
Multiple address selection is possible using a diode matrix as shown in fig. 4.

Fig. 4 - Multiple address selection



Note: Unused inputs can be left open or connected to GND

Keyboard

Commands can be given using a single contact matrix keyboard by means of which one row selection input (A to H) can be connected to one column selection input (K to Q): the transmitter is activated by this connection.
To have an input command accepted, the contact must be continuously closed for a minimum of ~ 25 ms.
Internal circuitry rejects double or multiple contacts.
If the key is operated continuously, the command is repeated every ~ 102 ms (f_{ref}= 500 kHz).
When the key is released the circuit transmits the end-of-transmission code after about 18 ms and returns to stand-by mode.
The same occurs when the key is released whil command is being transmitted, after the circuit carried out the present transmission.
No command is accepted until the end of transmission code is over.

TDA 2320 - Infrared signal preamplifier

Supply voltage: 4-16V
Tecnology: bipolar

The design of the infrared signal preamplifier is very simple: a standard operational amplifier can be used for this purpose (for example the TDA 2320 - see application part) which can be used both in flash and carrier operating modes.
Our proposed configuration can achieve 70 dB gain and under normal light conditions the system, in case of single command, can be controlled in the range 0 to 20 meters.

M104 – Remote control receiver

Power supply: 5V ± 5%
Technology: NMOS

This device is a remote control receiver which can decode the information transmitted by the M709/M710 working in the flash mode. Due to the highly reliable code of the transmission, only correct information is accepted and decoded by the M104.

The transmitted commands are accepted only if correspondence exists between the transmitted Address and the Address code selected at the receiver (2 address codes are available at the receiver end). After accepting a command, the device releases the related code on the serial data bus, whose clock rate is of 62.5 kHz (f_{osc}= 500 kHz).

The device can directly address a Program Memory with up to 32 different programs (also a Program Store output is provided to complete the memory ...ding feature) and can control up to 4 different analogue variables (e.g. volume, brightness, colour saturation, contrast in TV sets).

A block diagram of the device is shown in fig. 5. Detailed features are described in the following points.

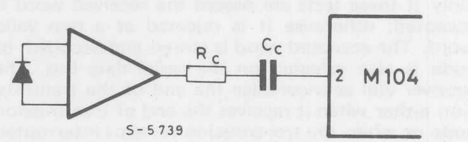
Oscillator

Two pins are provided for the oscillator connections in the M104: a cheap ceramic resonator can be used, whose nominal frequency can range from 455 to 500 kHz (actual frequency can range from 445 to 510 kHz).
Due to the synchronization between the transmitter and the receiver time bases operated in the M104, a resonator varying in the same range can be used in the transmitter: so the system needs neither the use of resonators with the same frequency in the transmitter and in the receiver nor frequency adjustments for synchronization. Also an L–C group may be used as the frequency reference of the receiver: see application part.

I.R. signal decoding

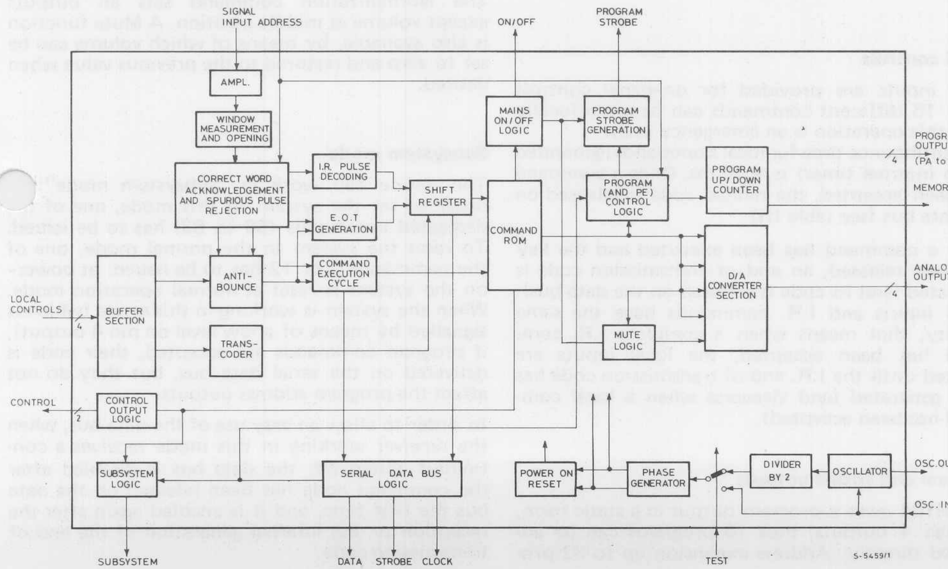
The device can sense I.R. signal inputs with V_{ppmin}= 0.5V. The signal must be a.c. coupled to this input (see fig. 6), which has an internal self-biasing structure for maximum gain purpose. Signals with V_{ppmax} up to 13.2V can be applied (with $R_C \geqslant 10\ K\Omega$, $C_C \leqslant 4.7\,nF$).

Fig. 6 – I.R. input connection



The receiver input section first synchronises the transmitter and the receiver time bases: this synchronization has been introduced in order to allow the use of different clock oscillators for the transmitter and the receiver, provided that both are in the specified range of 445 to 510 kHz. The synchronization is performed by the receiver measuring the interval between the start pulse and the first data pulse: since this interval is equal to the time base "T" for the transmission, the receiver stores this value and uses it as time base to decode the received signal.

Fig. 5 – M104 block diagram



The only requirement necessary for this kind of synchronization is that both oscillator frequencies remain constant within the transmission period of a command (this requirement is fulfilled very easily).
To achieve a good noise immunity, the receiver performs the following tests (see application part, for more detail):

- check of the position of the pulses (opening accepting windows at the time bases)
- check of the correct value of the parity bit
- check of the absence of pulses between the parity bit and the stop pulse
- check of noise level (parasitic transients are checked inside and outside the time windows).

Only if these tests are passed the received word is accepted; otherwise it is rejected as a non valid word. The accepted word is stored and decoded: its code is also released on the serial data bus. The receiver will acknowledge the end of the transmission either when it receives the end of transmission code or when the transmission remains interrupted for more than 550 ms (an internal timer is dedicated to this purpose). Also the end of transmission code (both accepted and generated) is released on the serial data bus. The receiver decodes only signals transmitted with the right address code.
One pin (pin 3) is dedicated to this purpose, so two different address codes can be used in the receiver:

Address	Pin 3
1	Low
2	High

The I.R. command truth table is shown below (table II).

Local controls

Four inputs are provided for on-panel controls (only 15 different commands can be given locally since this operation is an emergency one).
The antibounce time for local commands (generated by an internal timer) is ≃ 40 ms. Once a command has been accepted, the related code is released on the data bus (see table III)

After a command has been executed and the key has been released, an end-of-transmission code is generated (and its code is released on the data bus). Local inputs and I.R. commands have the same priority, that means when a complete I.R. command has been accepted, the local inputs are blocked until the I.R. end of transmission code has been generated (and viceversa when a local command has been accepted).

Program and strobe outputs

The M104 gives a program output in a static form, through 4 outputs; thus 16 programs can be addressed directly. Address expansion up to 32 programs can be achieved by means of the static output PE if the receiver operates with Address 1 (otherwise, PE is an additional general purpose memory). At power-on reset all program output pins (including PE) are set low, so program 1 is addressed. The program selection can be direct (only from remote control) or sequential (both from remote control and from local keyboard). All program commands can be used to switch the TV set on. When the system is in the "subsystem mode" no program command is executed
A Program strobe output is also provided, which gives a negative pulse every time the external program memory has to be read: this signal is available only when program commands are executed.

Analogue control outputs

Four open drain outputs are provided to control analogue functions (e.g. volume, brightness, colour saturation, contrast in TV sets).
The analogue information is given in form of the duty cycle of a square waveform delivered from the outputs. The conversion is made by means of the pulse width modulation principle: output frequency is 7.8 kHz, and the duty cycle is variable in 64 steps. A simple low pass filter can be externally used to convert the variable duty cycle into a DC voltage.

At power-on reset the volume output is set at duty cycle 21/64, while other outputs are set at middle position (duty cycle = 31/64).
The analogue values can be varied both from remote control and from local keyboard: the change in duty cycle can be obtained both step-by-step and continuously (in this case the rate of variation is of one step every ≃ 102 ms with remote control and every ≃ 115 ms with local keyboard).

The Normalization command sets all outputs except volume at middle position. A Mute function is also available, by means of which volume can be set to zero and restored to the previous value when desired.

Subsystem mode

The device can work in "subsystem mode": in order to set the system to this mode, one of the dedicated commands (56 to 63) has to be issued. To reset the system to the normal mode, one of the commands 2 or 12 has to be issued: at power-on the system is reset at normal operation mode. When the system is working in this mode (which is signalled by means of a low level on pin 4 output), if program commands are accepted, their code is delivered on the serial data bus, but they do not affect the program address outputs.

In order to allow an easy use of the data bus, when the receiver working in this mode receives a continuous command, the data bus is disabled after the command code has been released on the data bus the first time, and it is enabled again after the reception or the internal generation of the end of transmission code.

	C1	C2	C3	C4	C5	C6	A	B	C	D	C1	C2	C3	C4	C5	C6	
0	0	0	0	0	0	0					L	L	L	L	L	L	End of transmission.
1	1	0	0	0	0	0					H	L	L	L	L	L	Mute on/off
2	0	1	0	0	0	0	L	L	L	L	L	H	L	L	L	L	Mains off/Mute off/Subsyst. off (pin 4 H)
3	1	1	0	0	0	0					H	H	L	L	L	L	
4	0	0	1	0	0	0					L	L	H	L	L	L	
5	1	0	1	0	0	0					H	L	H	L	L	L	
6	0	1	1	0	0	0					L	H	H	L	L	L	Control 1 L
7	1	1	1	0	0	0					H	H	H	L	L	L	Control 2 L
8	0	0	0	1	0	0	L	H	H	H	L	L	L	H	L	L	Program +/Mains on
9	1	0	0	1	0	0	H	L	H	H	H	L	L	H	L	L	Program –/Mains on
10	0	1	0	1	0	0	L	L	L	H	L	H	L	H	L	L	Normalization/Mute off
11	1	1	0	1	0	0					H	H	L	H	L	L	
12	0	0	1	1	0	0					L	L	H	H	L	L	Mains on/Subsystem off (pin 4 H)
13	1	0	1	1	0	0	H	H	L	L	H	L	H	H	L	L	Memory 1 L
14	0	1	1	1	0	0	H	H	H	L	L	H	H	H	L	L	Memory 1 H
15	1	1	1	1	0	0					H	H	H	H	L	L	
16	0	0	0	0	1	0					L	L	L	L	H	L	Program 16/Mains on
17	1	0	0	0	1	0					H	L	L	L	H	L	Program 1/Mains on
18	0	1	0	0	1	0					L	H	L	L	H	L	Program 2/Mains on
19	1	1	0	0	1	0					H	H	L	L	H	L	Program 3/Mains on
20	0	0	1	0	1	0					L	L	H	L	H	L	Program 4/Mains on
21	1	0	1	0	1	0					H	L	H	L	H	L	Program 5/Mains on
22	0	1	1	0	1	0					L	H	H	L	H	L	Program 6/Mains on
23	1	1	1	0	1	0					H	H	H	L	H	L	Program 7/Mains on
24	0	0	0	1	1	0					L	L	L	H	H	L	Program 8/Mains on
25	1	0	0	1	1	0					H	L	L	H	H	L	Program 9/Mains on
26	0	1	0	1	1	0					L	H	L	H	H	L	Program 10/Mains on
27	1	1	0	1	1	0					H	H	L	H	H	L	Program 11/Mains on
28	0	0	1	1	1	0					L	L	H	H	H	L	Program 12/Mains on
29	1	0	1	1	1	0					H	L	H	H	H	L	Program 13/Mains on
30	0	1	1	1	1	0					L	H	H	H	H	L	Program 14/Mains on
31	1	1	1	1	1	0					H	H	H	H	H	L	Program 15/Mains on
32	0	0	0	0	0	1	L	H	L	H	L	L	L	L	L	H	Volume +/Mute off
33	1	0	0	0	0	1	L	L	H	H	H	L	L	L	L	H	Volume –
34	0	1	0	0	0	1	H	L	L	H	L	H	L	L	L	H	Analogue 2 +
35	1	1	0	0	0	1	L	H	H	L	H	H	L	L	L	H	Analogue 2 –
36	0	0	1	0	0	1	H	L	H	L	L	L	H	L	L	H	Analogue 3 +
37	1	0	1	0	0	1	L	L	H	L	H	L	H	L	L	H	Analogue 3 –
38	0	1	1	0	0	1	L	H	L	L	L	H	H	L	L	H	Analogue 4 +
39	1	1	1	0	0	1	H	L	L	L	H	H	H	L	L	H	Analogue 4 –
40	0	0	0	1	0	1					L	L	L	H	L	H	
41	1	0	0	1	0	1					H	L	L	H	L	H	
42	0	1	0	1	0	1					L	H	L	H	L	H	
43	1	1	0	1	0	1					H	H	L	H	L	H	
44	0	0	1	1	0	1					L	L	H	H	L	H	
45	1	0	1	1	0	1					H	L	H	H	L	H	
46	0	1	1	1	0	1					L	H	H	H	L	H	
47	1	1	1	1	0	1					H	H	H	H	L	H	
48	0	0	0	0	1	1					L	L	L	L	H	H	
49	1	0	0	0	1	1					H	L	L	L	H	H	
50	0	1	0	0	1	1					L	H	L	L	H	H	
51	1	1	0	0	1	1					H	H	L	L	H	H	
52	0	0	1	0	1	1					L	L	H	L	H	H	
53	1	0	1	0	1	1					H	L	H	L	H	H	
54	0	1	1	0	1	1					L	H	H	L	H	H	
55	1	1	1	0	1	1					H	H	H	L	H	H	
56	0	0	0	1	1	1					L	L	L	H	H	H	Subsystem mode on
57	1	0	0	1	1	1					H	L	L	H	H	H	Subsystem mode on
58	0	1	0	1	1	1					L	H	L	H	H	H	Subsystem mode on
59	1	1	0	1	1	1					H	H	L	H	H	H	Subsystem mode on (pin 4 L)
60	0	0	1	1	1	1					L	L	H	H	H	H	Subsystem mode on
61	1	0	1	1	1	1					H	L	H	H	H	H	Subsystem mode on
62	0	1	1	1	1	1					L	H	H	H	H	H	Subsystem mode on
63	1	1	1	1	1	1					H	H	H	H	H	H	Subsystem mode off (pin 4 H)

Note : All the program and shift commands (13, 14) are blocked when one of the commands from 56 to 62 is issued. This condition is reset by commands 2, 12 and 63.

TABLE III – Local command truth table

Inputs				Data bus codes						Function
A	B	C	D	C1	C2	C3	C4	C5	C6	
H	H	H	H							
L	H	H	H	L	L	L	H	L	L	Program +
H	L	H	H	H	L	L	H	L	L	Program –
L	L	H	H	H	L	L	L	L	H	Volume –
H	H	L	H	H	H	L	L	L	L	
L	H	L	H	L	L	L	L	L	H	Volume +
H	L	L	H	L	H	L	L	L	H	A 2 +
L	L	L	H	L	H	L	H	L	L	Normalization
H	H	H	L	L	H	H	H	L	L	Memory 1 H
L	H	H	L	H	H	L	L	L	H	A 2 –
H	L	H	L	L	L	H	L	L	H	A 3 +
L	L	H	L	H	L	H	L	L	H	A 3 –
H	H	L	L	H	L	H	H	L	L	Memory 1L
L	H	L	L	L	H	H	L	L	H	A 4 +
H	L	L	L	H	H	H	L	L	H	A 4 –
L	L	L	L	L	H	L	L	L	L	Mains off

Mains ON/OFF circuit

An internally latched signal is available at pin 28 of the device, which can be used to control the on/off switching of the TV set (via a transistor and a relay). The TV set will be switched on when this output is low.

At power-on, the output is automatically switched off so the TV system is set in stand-by. During stand-by only the Mains on commands are accepted, while all the others are rejected. TV set can be switched on by means of one of the folliwing commands:

- program +/– (in this case the command does not affect the program outputs)
- direct program calling
- mains on command (command 12)

In order to improve noise immunity, a Mains on command is accepted only if it is continuously received 5 times ($\simeq$ 0.4 sec).

In order to allow the use of a temporarily active slide contact in parallel with the master power-on switch, the TV can be switched on connecting pin 28 to ground for at least 10 μs.

To put the system in the stand-by mode, the mains off command can be issued (command n. 2). This command (which must be continuously received for about 400 ms) is available also on the local keyboard.

Other features

Two control outputs are provided at pin 9 and 10. They consist of open drain transistors that are switched on when commands 6 and 7 respectively are issued (see truth table).

Command	R1 (pin 10)	R2 (pin 9)
6	L	H
7	H	L

The output corresponding to the issued comm... remains low for about 160 ms (147 to 173 ms) after the reception of the command.

Serial data bus

The M104 serial data bus consists of three lines:

- strobe (active low)
- data (data are inverted)
- clock

The code of each accepted command, both local and remote, is released on this serial bus in order to control external circuits (Teletext, Viewdata, Videorecorder, etc). For the serial data bus configuration and timing and for more details, see application part.

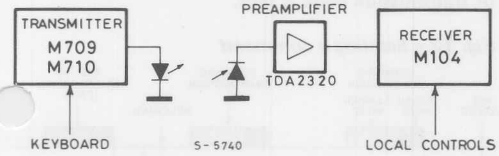
TV APPLICATION NOTES

This part describes the application of the Remote Control system on a TV and is divided in three main parts:

- Transmitter
- Preamplifier
- Receiver

The block diagram of the Remote Control system is shown in fig. 7.

Fig. 7 - Block diagram of the remote control system



Transmitter

A typical application of the M709/M710 is shown in fig. 8. For up to 40 commands the M709 is used. If more commands are necessary, the M710 can be used.

Clock oscillator

As clock reference a cheap ceramic resonator with a frequency between 445 kHz and 510 kHz is connected between pins 2 and 3.

A common value of frequency is 500 kHz (MURATA CSB 500). Instead of the ceramic resonator an LC group can be used: in this case it is better to check that the oscillation frequency is between the two above-mentioned values (see fig. 9).

Address inputs

These inputs can be connected to ground or to V_{DD} to choose the desired address to be transmitted with the command code. The address inputs are pulled down; therefore if address one is chosen, all the inputs can be left open.

If the transmitter works in conjunction with the M104 receiver, only addresses one or two must be used: if another decoder system is foreseen, for example a microprocessor, all the sixteen addresses could be used.

Transmission mode

Two transmission modes are provided: flash or carrier mode. A pin is provided to select the operating mode. When working with the M104 receiver flash mode is used and the pin is kept high (V_{DD}).

Driving infrared LED

A characteristic of this transmission system is the low duty-cycle which allows to drive the infrared transmitter LEDs with a relatively high peak current and a low average power consumption.

Fig. 8 - M709/710 typical application

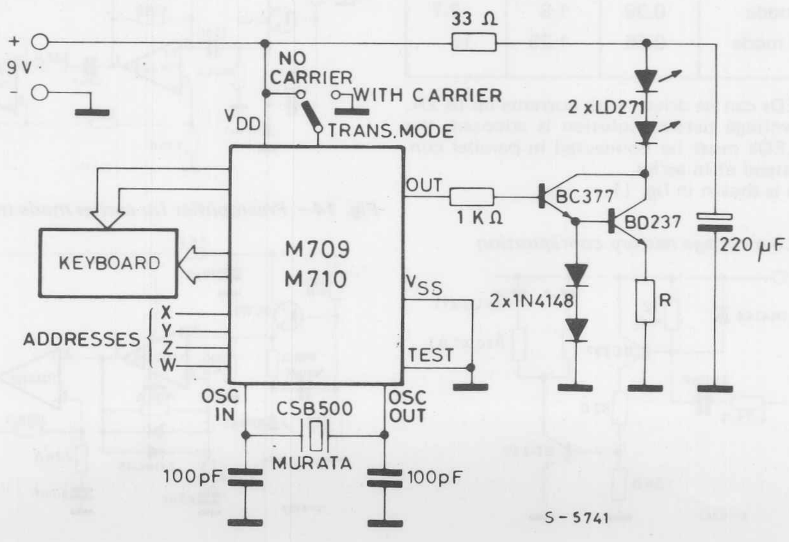
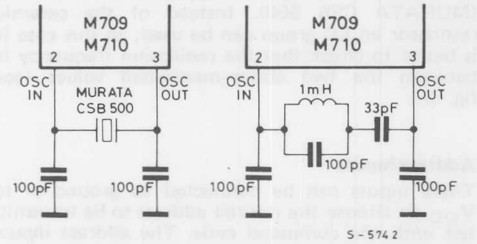
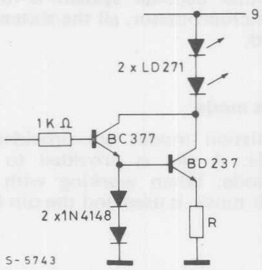


Fig. 9 – M709/710 clock oscillator connections



The driving stage is connected so to have a current generator configuration (fig. 10).

Fig. 10 – Driving I.R. LEDs



The current can be adjusted by means of resistor R:

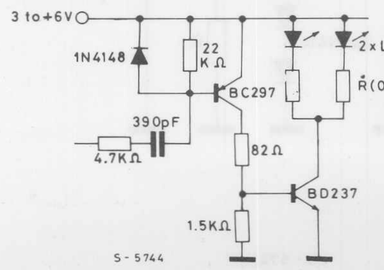
$$I \simeq \frac{0.7}{R}$$

The value of R is chosen in function of the desired power consumption and transmission mode.

Transmission mode	R (Ω)	I peak (A)	I average (mA)
Flash mode	0.39	1.8	2.7
Carrier mode	0.56	1.25	13

The IR LEDs can be driven with currents up to 2A. If a low voltage battery solution is adopted, the infrared LEDs must be connected in parallel connection instead of in series.
A solution is shown in fig. 11.

Fig. 11 – Low voltage battery configuration

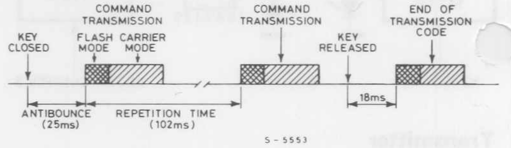


The power consumption depends on the supply voltage and the value of R.
If you want to obtain the same results with this circuit compared with those of the previous one, you must set the same current flowing in the IR LEDs.

Keys

The row–columns matrix is intended for use with simple single pole keys: a rubber conductive key can also be used provided that the serial resistance of the closed key is less than 2.5 kΩ. In order to be accepted, the key must be closed for a least 25 ms: every time an accepted key is released, the end of transmission code is sent.

Fig. 12 – Sending a command



Preamplifier

Two types of preamplifier are available according to the type of transmission mode used. Both the types are designed around the TDA 2320.
The preamplifier for the flash mode transmission is not band limited while for the carrier mode transmission it is a band pass centered around 38 kHz. The two application circuits are shown in fig. 13 and fig. 14.

Fig. 13 – Preamplifier for flash mode transmission

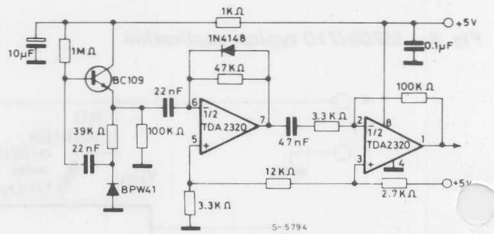


Fig. 14 – Preamplifier for carrier mode transmission

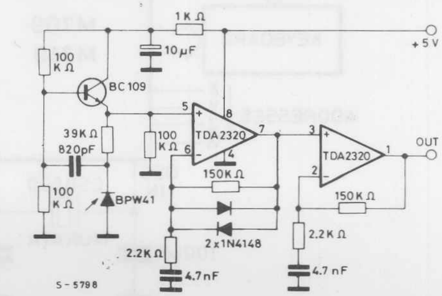
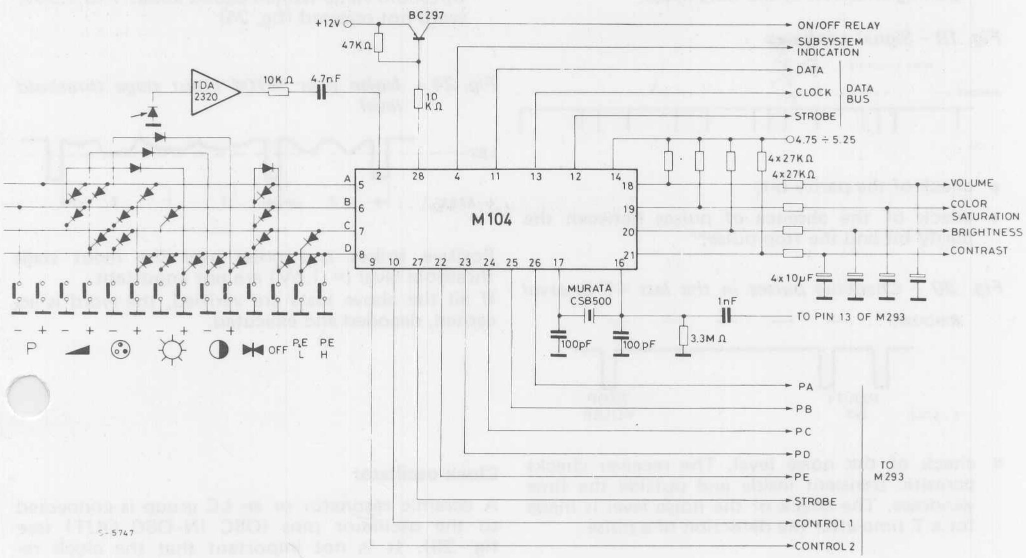


Fig. 15 - M104 typical application



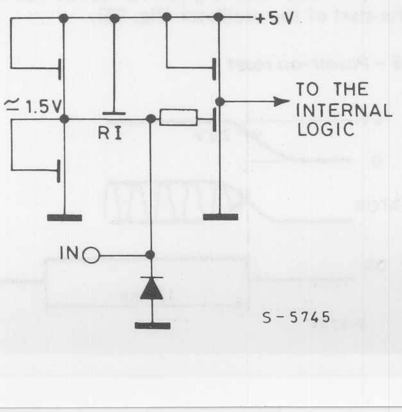
Receiver

The complete application circuit is outlined in fig. 15, and the truth table (TV application) in table II.
The receiver works only with the flash mode transmission system.

Signal input

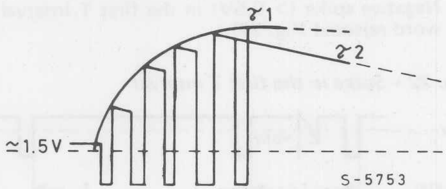
The signal coming from the preamplifier is brought to this pin. The input is self-biasing at a voltage of about 1.5V. The schematic diagram of the input is shown in fig. 16.

Fig. 16 - M104 input stage



The amplitude of the signal must be ⩾ 0.5V while the minimum width is about 8 μs: the maximum is not important.
When a strong signal is applied to the pin, a level shift of the same signal is visible due to the different RC constants: during the pulse signal the RC constant is about 4.7 nF x 10 kΩ (coupling network 10 kΩ, 4.7 nF) (τ 1) while between two pulses it is about 4.7 nF x internal resistor RI (300 kΩ to 1 MΩ) (τ2), see fig. 17.

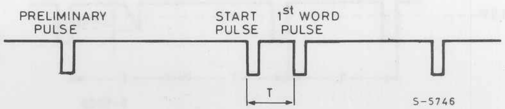
Fig. 17 - Strong signal level shift



The tests on the incoming signal are the following:

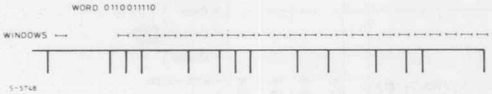
- measurement of the pulse distance T (time base synchronization).

Fig. 18 - Time base



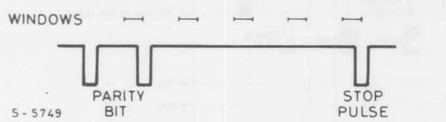
- check of the position of the received bits opening windows at the time bases;

Fig. 19 - Signal windows



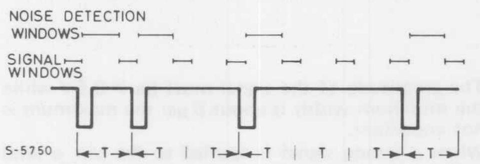
- check of the parity bit;
- check of the absence of pulses between the parity bit and the stop pulse;

Fig. 20 - Checking pulses in the last 4T interval



- check of the noise level. The receiver checks parasitic transient inside and outside the time windows. The check of the noise level is made for a T time after the detection of a pulse.

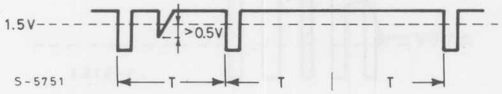
Fig. 21 - Noise windows



For this reason it is very important that the signal has not double pulses or spurious spike in the T time after the time pulse: if the spike occurs during the second T time, it has no effect on the signal decoding.
The following cases are possible:

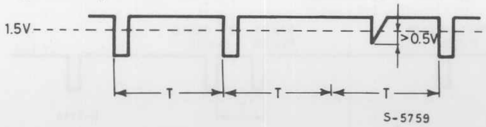
- Negative spike (> 0.5V) in the first T interval: word rejected (fig. 22).

Fig. 22 - Spike in the first T interval



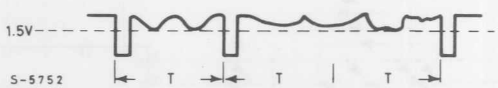
- Negative spike in the second T interval: word not rejected (fig. 23).

Fig. 23 - Spike in the second T interval



- Noise and spike not under the M104 input stage threshold value (which equals about 1 to 1.5V): word not rejected (fig. 24).

Fig. 24 - Noise over M104 input stage threshold level

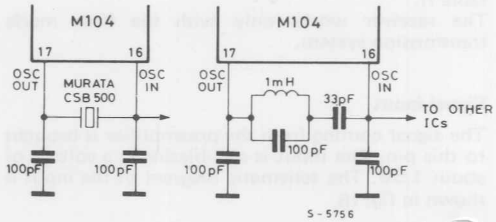


Positive spikes and noise over the input stage threshold level (≃ 1.5V) are not important.
If all the above tests are verified, the word is accepted, decoded and executed.

Clock oscillator

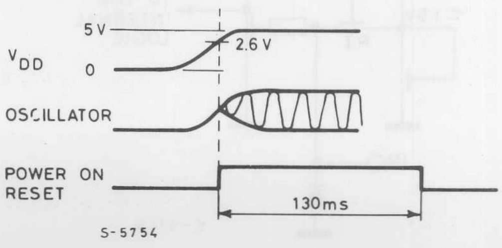
A ceramic resonator or an LC group is connected to the oscillator pins (OSC IN-OSC OUT) (see fig. 25). It is not important that the clock rereference has the same value as that of the transmitter provided that it is within the permitted range of frequency (445 to 510 kHz). From pin 16 (oscillator input) one can derive the clock for other uses (i.e. for the M293 system).

Fig. 25 - M104 clock oscillator connections



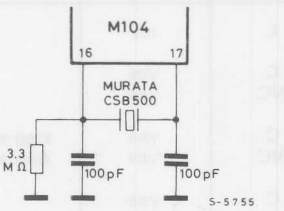
The power-on reset is associated to the clock oscillator pin: this reset is given for about 130 ms after the start of the oscillator (fig. 26).

Fig. 26 - Power-on reset



To have a surer power-on reset it is better to connect a 3.3 MΩ resistor between pin 16 and ground (fig. 27).

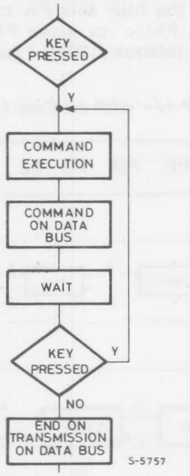
Fig. 27 - Improving the power-on reset



Local controls

The local controls and the corresponding codes are shown in table III of the previous section.
All the keys are ground referred and the corresponding codes at the A-B-C-D inputs are obtained by means of direct or diode connections between the same inputs and the keys. An internal antibounce circuit accepts the pressed key after ≃ 40 ms of its continuous presence. When a pressed key is released, the end of transmission code is sent on the data bus (fig. 28).

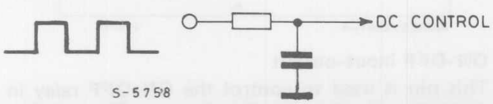
Fig. 28 - Local control flow chart



Analogue outputs

These outputs are used to control four analogue functions.
The control analogue value is obtained by filtering a square wave whose frequency is 7.8 kHz with a 64 step variable duty-cycle (fig. 29).

Fig. 29 - Analogue control



The outputs are open drain: the pull-up resistors can be connected to a supply voltage of up to of 13.5V.

The analogue outputs vary as shown in table IV.

Table IV – Analogue outputs value

Command	Volume	AN 2	AN 3	AN 4
Power on Reset	21/64	31/64	31/64	31/64
Vol +/– (32, 33)	↑↓	NC	NC	NC
AN 2 +/– (34, 35)	NC	↑↓	NC	NC
AN 3 +/– (36, 37)	NC	NC	↑↓	NC
AN 4 +/– (38, 39)	NC	NC	NC	↑↓
Normal (10)	NC	31/64	31/64	31/64
Mute on (1)	0/64	NC	NC	NC
Mute off (1)	Previous value	NC	NC	NC

NC = No Change.

The variation rate is (f_{ref}= 500 kHz):

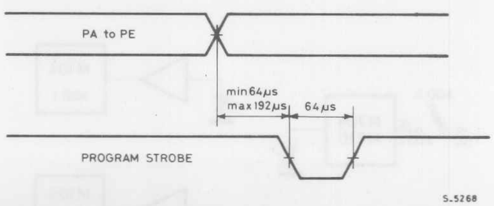
– command from remote control: 102 ms
– command from local control: 115 ms.

PA, PB, PC, PD, PE and Strobe outputs

Pins PA to PE are open drain, binary coded, static outputs usually used to address a program in the EPM system. The strobe output is a signal that is active every time there is a command concerning PA to PE. The work of PA to PE and strobe output depends on the address input of the M104 (Table V).

The relation between PA to PE and strobe output is shown in fig. 30.

Fig. 30 - PA to PE and strobe timing relation



The strobe signal is available once only.

Table V – PA to PE and Strobe outputs

Command		PA to PD	PE	Strobe	Condition
Power on reset		L L L L	L	no	
Direct selection (16 to 31)	Ad1	C	C	yes	
	Ad2	C	NC	yes	
P +/– (8, 9)	Ad1	C	C	yes	step every 0.57 sec.
	Ad2	C	NC	yes	step every 0.57 sec.
Shift (13, 14)	Ad1	NC	C	yes	
Memory 1	Ad2	NC	C	no	

NC = No Change C = Change Subsystem off.

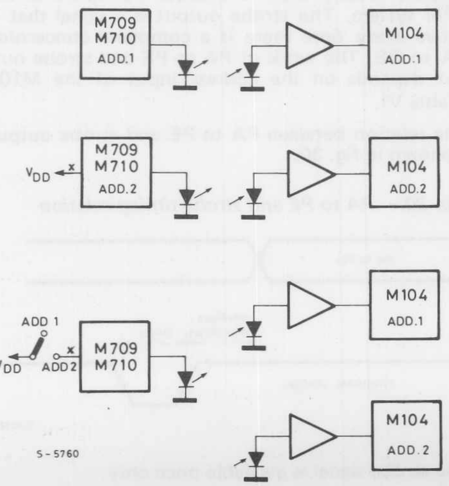
Address input

The M104 has the possibility of working with two addresses (1 or 2).

When address one is chosen, the M104 will respond only to a transmitter with address one while, when address two is chosen, it responds to a transmitter with address two.

With this system, receivers with two different addresses can work at the same time without disturbing each other; for example, one receiver can be dedicated to the TV set and the other one to the HI-FI set: in this case the transmitters will be two with different addresses or one with a switch on address inputs (see fig. 31).

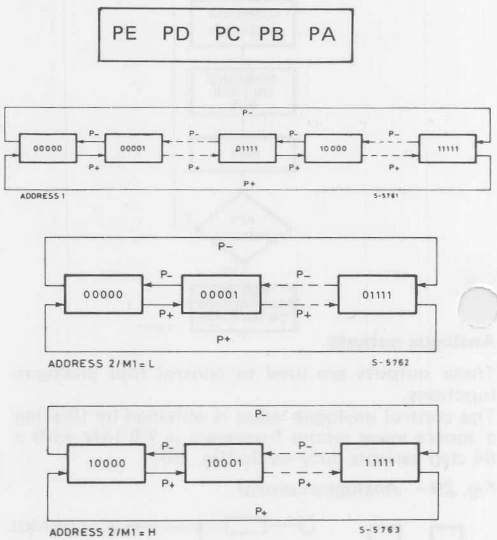
Fig. 31 – TX and RX with different addresses



The choise of the address affects also the working of the fifth bit PE during the command P+/P– (Program +/–).

With address one all the five bit counter is incremented or decremented while, using address two, only the four bits PA to PD respond to the commands P+/–: to move PE there are separate commands (Memory 1 H/L) (see fig. 32).

Fig. 32 – P +/– with address 1 and 2



ON-OFF input-output

This pin is used to control the ON-OFF relay in systems with the standby feature. The relation between this output and the commands is shown in Table VI. When this output is low, the TV set is switched on.

Table VI – ON/OFF output

Command	Output pin 28	Condition
Power on reset	OFF	
P +/– (8, 9)	ON	Received 5 times
Mains on (12)	ON	Received 5 times
Program selection (16 to 31)	ON	Received 5 times
Mains off (2)	OFF	Received 5 times
Pin 28 to GND	ON	At least 10 μs to GND

If the stand-by function is not used the ON-OFF input-output must be connected to V_{SS}.
The circuit to drive the ON-OFF relay can be the one in fig. 33 for relays up to 12V or the one in fig. 34 for relays with a supply voltage higher than 12V.

Fig. 33 – Relay supply voltage ⩽ 12V

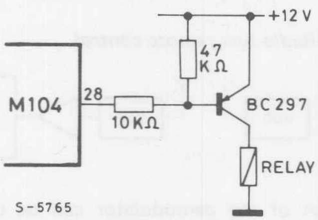
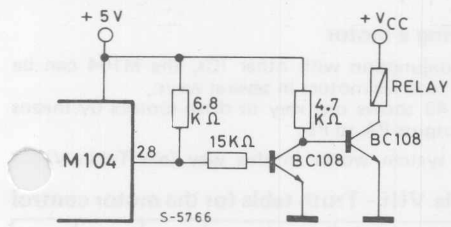


Fig. 34 – Relay supply voltage > 12



Subsystem mode indication

The M104 system is foreseen for use with other external circuits such as HI-FI sets, Videorecorder, Viewdata, Teletext and so on. These external circuits can be seen as subsystems driven by means of the M104 data bus. The subsystem condition is indicated by a low level on pin 4.

When the M104 is in subsystem mode, the program commands [16 to 32] are not executed and all the commands received (locally or remotely) are released only once on the data bus. The subsystem output behaves as shown in Table VII.

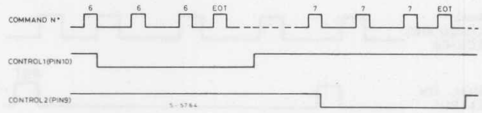
Table VII – Subsystem output

Command	Subsystem output (pin 4)
Power on Reset	OFF
Subsystem on (56 to 62)	ON
Subsystem off (63)	OFF
Mains off (2)	OFF
Mains on (12)	OFF

Control outputs

These outputs are general purpose: they could be used, for example, with the M293 (tuning system) to perform functions such as fine tuning or station search. These outputs are open drain and are active for all the time during which the corresponding code is sent from the infrared transmitter:

Fig. 35 – Control outputs

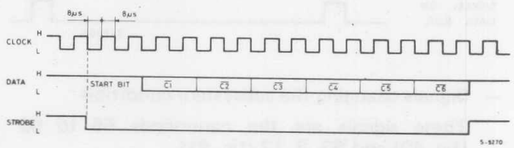


As soon as the command transmission is stopped, the control output is reset (high level) after a time varying from 144 to 173 ms (f = 500 kHz) (see fig. 35).

Serial data bus

The serial data bus consists of three signals: strobe, data and clock (fig. 36).

Fig. 36 – Serial data bus

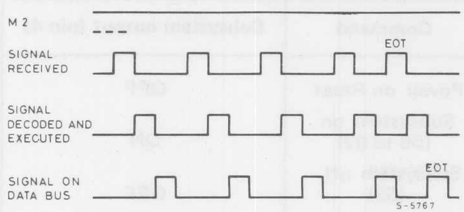


The codes of all the received commands are released on the data bus; in case of commands sent continuously the codes are output on the data bus at each command received if the subsystem is off or only once if the subsystem is on.
The working of the bus is linked to the subsystem condition in the following ways:

– Subsystem output OFF (H)

All the commands received are continuously sent to the data bus: also the end of transmission (EOT) is sent (fig. 37).

Fig. 37 - System behaviour with subsystem OFF



— Subsystem output ON (L)

All the commands received are sent only once to the data bus: the EOT is also sent (fig. 38). The program commands are not executed but are sent to the data bus (fig. 39).

Fig. 38 - System behaviour with subsystem on

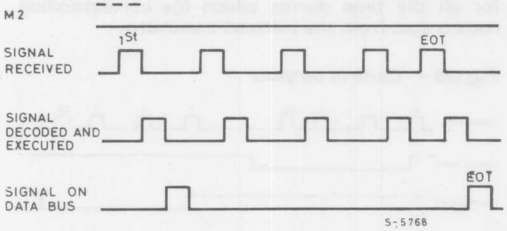
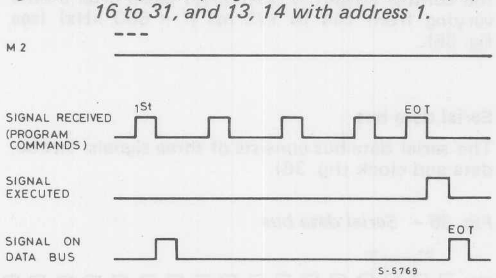


Fig. 39 - Subsystem program on: commands 8, 9, 16 to 31, and 13, 14 with address 1.



— Signals changing the subsystem condition

These signals are the commands 56 to 62 (fig. 40) and 63, 2, 12 (fig. 41).

Fig. 40 - Subsystem on commands 56 to 62

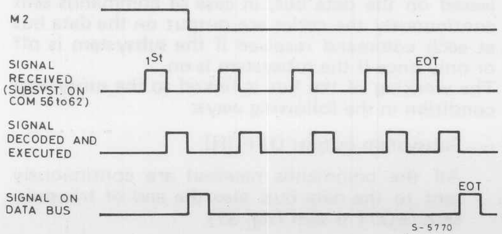
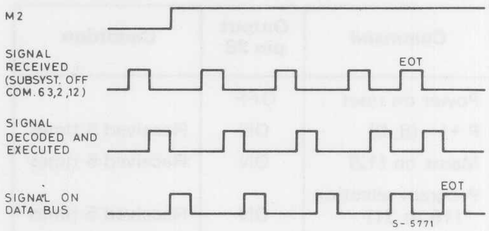


Fig 41 - Subsystem off commands 2, 12, 63



OTHER APPLICATIONS

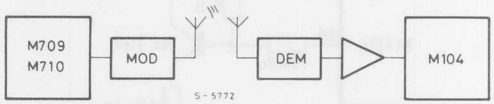
Remote control via a radio link

Instead of an infrared link a radio link can be used to obtain some further features:

- more reliable transmission
- no directivity problems
- long distances

This solution is used in industrial applications with the following schematic diagram: (fig. 42)

Fig. 42 - Radio link remote control



The output of the demodulator can be directly coupled to the M104 if the signal level is high enough: viceversa a preamplifier must be inserted between the modulator and the M104.

Driving a motor

In conjunction with other ICs, the M104 can be used to drive motors in several ways.

Fig 43 shows one way to drive motors by means of outputs PA to PE.

The system works in this way (see Table VI

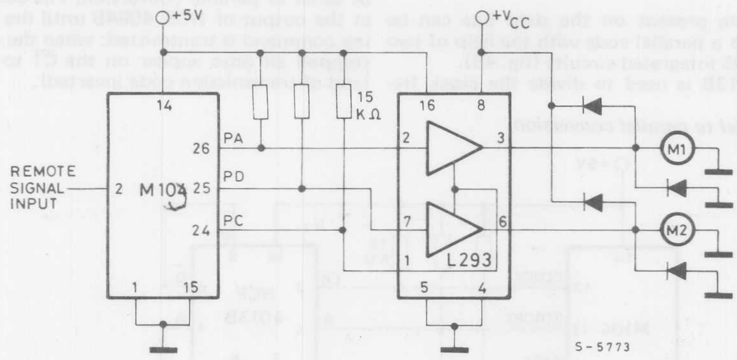
Table VIII - Truth table for the motor control

Command	PA	PB	PC	M1	M2
Power ON	0	0	0	OFF	OFF
22	1	0	1	ON	OFF
23	0	1	1	OFF	ON
24	1	1	1	ON	ON
20	X	X	0	OFF	OFF

PC is used as inhibit: when it is at low level the motor are switched off.

PA controls motor 1 while PB controls motor 2.

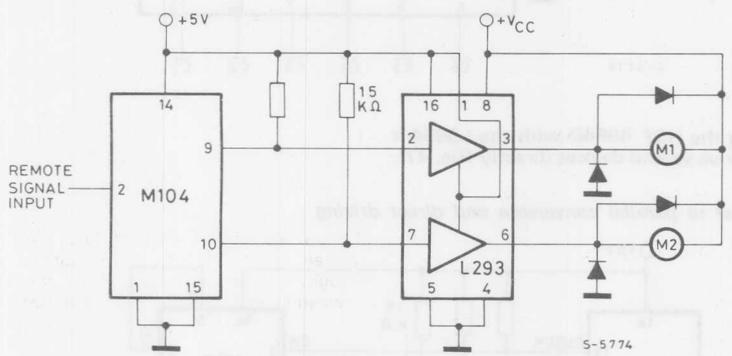
Fig. 43 – Motor driving with M104 and L293



The L293 contains other two drivers therefore up to four motors can be driven.

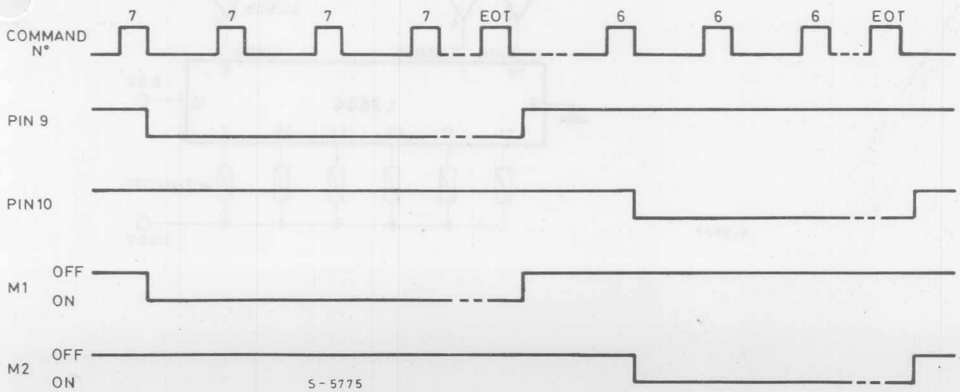
Fig. 44 shows a circuit for driving a motor with the control outputs (pin 9 - 10).

Fig. 44 – Motor driving with M104 and L293



Motor M1 works when pin 9 is low and therefore when command 7 is issued from the remote control transmitter: the motor continues working until the command is sent. The same is valid for M2 but referring to pin 10 and command 6 (fig. 45).

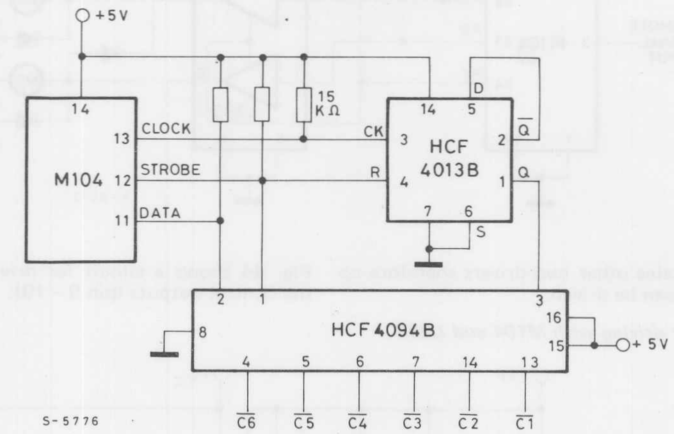
Fig. 45 – Timing diagram for motor control



Data bus serial to parallel conversion

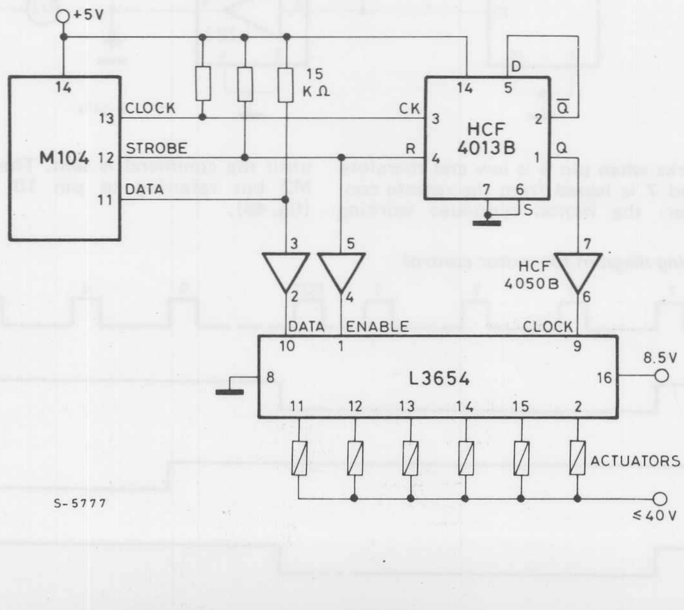
The serial data present on the data bus can be converted into a parallel code with the help of two standard CMOS integrated circuits (fig. 46).
The HCF 4013B is used to divide the clock frequency while the HCF 4094B performs the function of serial to parallel conversion. The code is present at the output of HCF 4094B until the corresponding command is transmitted: when the command is stopped all ones appear on the $\overline{C1}$ to $\overline{C6}$ outputs (end of transmission code inverted).

Fig. 46 - Serial to parallel conversion



By substituting the HCF 4094B with the L3654 it is possible to drive several devices directly (fig. 47).

Fig. 47 - Serial to parallel conversion and direct driving



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